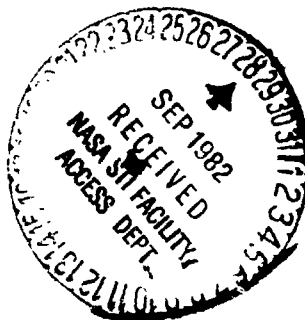


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2069**

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Atmospheric Constraint Statistics for the Space Shuttle Mission Planning

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**O. E. Smith,
G. W. Batts,
and J. A. Willett**



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Atmospheric Constraint Statistics for the Space Shuttle Mission Planning

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TECHNICAL PAPER

ATMOSPHERIC CONSTRAINT STATISTICS FOR THE SPACE SHUTTLE MISSION PLANNING

I. INTRODUCTION

This report describes the procedures that have proven to be effective in addressing specific questions on the frequency of atmospheric conditions of interest for the Space Shuttle mission planning. There are several atmospheric parameters of interest for each of the mission phases. The mission phases considered are (1) pre-launch, (2) launch operations, (3) return to launch site (RTLS), (4) abort once around (AOA), and (5) end of mission landing (EOM). Most standard statistical summaries of atmospheric variables are tabulated for single variables or a combination of a few variables such as cloud ceilings and visibilities. That is, they are parametric statistical summaries. Here, the interest is not only in the probability of each of the several atmospheric variables taken separately, but also in the probability that at least one of several variables will be of concern for a particular mission phase and for the several mission phases. For example, if there is a launch constraint due to several atmospheric parameters of which any one is a No-Go condition, then the probability of interest is the probability that any one of the constraints will occur.

The purpose of the statistical analysis is to address the following questions relative to assigned atmospheric constraints for the Space Shuttle mission phases.

- 1) What is the probability that the assigned atmospheric constraints will (will not) occur during a particular monthly reference period?
- 2) What is the probability that the assigned atmospheric constraints will (will not) occur for N consecutive days at a particular time of day during a monthly reference period?
- 3) Once the assigned atmospheric constraint has occurred (has not occurred) for 1, 2, 3, ... J consecutive days at a particular time of day, what is the probability that the given constraints will continue for N additional days?

Valid answers to these questions have practical applications to the Space Shuttle program in the following interrelated areas:

- 1) Establishing the natural environment design criteria
- 2) Mission planning
- 3) Establishing launch and flight operational rules
- 4) Shuttle program decisions on cost-trade assessments.

All three questions can be adequately answered for the stated purposes provided that appropriate atmospheric data bases are available. Over the years of assigned roles, this organization has developed sufficiently long periods of atmospheric records to use empirical statistical methods for the Shuttle launch from the Kennedy Space Center (KSC) with the AOA and EOM at Edwards Air Force Base and Northrup Strip or AOA and EOM at KSC.

The first question, "What is the frequency?" is answered by simple empirical probabilities. The second and third questions on the continuation of atmospheric events are answered using empirical probabilities of runs and conditional probabilities.

It soon became apparent after issuing a report [1] that the Shuttle Program Office and the Mission Planning Office at the Johnson Space Center had requirements for answers to many specific questions on the atmospheric conditions. The choice was made to establish computer programs with many options to address these questions. Otherwise a very large volume of statistical tabulations to meet the expanding needs would be required -- an impractical approach.

The operations of the Atmospheric Mission Analysis computer programs have been performed to give statistical tabulations for assigned atmospheric constraints routinely on a 24-hr basis. The usage rate has been approximately 30 cases per month over the past year.

Section II gives a brief description of the atmospheric data bases, the atmospheric constraints options by mission phases, and the computer programs. Section III presents illustrative examples to demonstrate a few of the many possible statistical tabulations.

II. COMPUTER SYSTEM DESCRIPTION

A. Atmospheric Data Bases

1. KSC. The surface data used for this site is the WBAN hourly surface observations (Deck 144). The upper altitude wind data used is the two observations per day (Deck 600). The thunderstorm data used is the TD9688 data. The peak surface wind data used is the TD9690 data. All data used covered hours 0 through 23 with the exception of the upper altitude winds which were interpolated from the two observations per day to hourly observations. Period of record is January 1, 1957, through December 31, 1970.

2. Edwards Air Force Base. Data used for this site is the WBAN hourly surface observations (Deck 144). Period of record is January 1, 1957, through December 31, 1970.

3. Northrup Strip. Data used for this site is the WBAN hourly surface observations (Deck 144). Period of record is January 1, 1957, through December 31, 1970.

4. Vandenberg Air Force Base. The surface data used for this site is the WBAN hourly surface observations (Deck 144). The upper altitude wind data used is the two observations per day (Deck 600) which were interpolated to hourly observations. Period of record is January 1, 1965, through December 31, 1973.

B. Atmospheric Constraints by Mission Phases

1. Prelaunch Phase at KSC. There is one constraint for the prelaunch phase. There cannot be any precipitation during the hours of prelaunch activity. The beginning and ending hours for prelaunch activity are variable parameters.

2. Launch Phase at KSC. There are six constraint categories for the launch phase:

- 1) Thunderstorm – No-Go if a thunderstorm occurs.
- 2) Precipitation – No-Go if precipitation occurs.
- 3) Cloud ceiling and/or visibility – No-Go if the cloud ceiling is lower than specified and/or if the visibility is less than specified.
- 4) Peak surface wind speed – No-Go if the peak surface speed is greater than specified.
- 5) Upper altitude winds – No-Go if the max Q is greater than the specified U^* for the specified altitude region at the specified azimuth.
- 6) Tower clearance – No-Go if the peak surface wind is greater than specified for the wind direction. Wind from the directions of 150 to 210 degrees has a specified maximum while wind from all other directions may have a different specified maximum.

3. RTLS Phase. There are eight constraint categories for the RTLS phase:

- 1) Thunderstorm – Same as launch phase.
- 2) Precipitation – Same as launch phase.
- 3) Cloud ceiling and/or visibility – Same as launch phase except cloud cover may optionally be used instead of cloud ceiling.
- 4) Visibility – No-Go if visibility is less than specified.
- 5) Cloud cover – No-Go if cloud cover is greater than specified.
- 6) Head/tail wind – No-Go if the head or tail wind is greater than specified.
- 7) Steady state crosswind – No-Go if the steady state crosswind is greater than specified.
- 8) Peak crosswind – No-Go if the peak crosswind is greater than specified.
4. AOA. Same as for RTLS using the data base for the desired landing site.
5. EOM. Same as for RTLS using the data base for the desired landing site.

C. Techniques

1. Single Site. The desired analysis is performed on one site independently. For a KSC launch, the prelaunch, launch, and RTLS phases are for KSC only. An AOA or EOM phase may be performed on either Edwards Air Force Base, Northrup Strip, or KSC independent of each other.

2. Multiple Sites. The desired analysis is performed using all sites with each phase being dependent upon a Go condition for the previous phase. For example, the launch phase is only analyzed for those cases which are a Go condition from the prelaunch phase. The RTLS phase is only analyzed for those cases which are a Go condition from the launch phase. The AOA phase is only analyzed for those cases which are a Go

condition from the RTLS phase. The AOA phase uses each of the landing sites independently as well as jointly. Also, this technique allows for a launch window rather than a set launch hour.

3. Options. For the single site analysis, there are a total of 28 options which may be exercised at run time. Two of these options are for prelaunch operations, 15 options for the launch operations, and 11 options for the RTLS, AOA, or EOM operations.

- 1) Prelaunch operation beginning hour.
- 2) Prelaunch operation ending hour.
- 3) Launch thunderstorm constraint.
- 4) Launch precipitation constraint.
- 5) Launch cloud ceiling constraint.
- 6) Launch visibility constraint.
- 7) Launch surface peak wind speed constraint.
- 8) Launch azimuth for upper winds analysis.
- 9) Launch upper winds beginning altitude.
- 10) Launch upper winds ending altitude.
- 11) Launch U^* constraint for upper winds.
- 12) Launch option to disregard upper winds.
- 13) Launch tower clearance minimum wind direction.
- 14) Launch tower clearance maximum wind direction.
- 15) Launch tower clearance wind speed constraint for the winds occurring between the minimum and maximum wind direction.
- 16) Launch tower clearance wind speed constraint for the winds occurring at all other wind directions.
- 17) Launch wind type to be used for head/tail wind constraint (either steady state or peak winds may be used).
- 18) RTLS, AOA, and EOM runway angles which allow for up to two runways with the option to use any combination of landing directions.
- 19) RTLS, AOA, and EOM thunderstorm constraint.
- 20) RTLS, AOA, and EOM precipitation constraint.

- 21) RTLS, AOA, and EOM option to use either the cloud ceiling or cloud cover constraint.
- 22) RTLS, AOA, and EOM cloud ceiling constraint.
- 23) RTLS, AOA, and EOM visibility constraint.
- 24) RTLS, AOA, and EOM cloud cover constraint.
- 25) RTLS, AOA, and EOM head wind constraint.
- 26) RTLS, AOA, and EOM tail wind constraint.
- 27) RTLS, AOA, and EOM steady state crosswind constraint.
- 28) RTLS, AOA, and EOM peak crosswind constraint.

For the multiple site analysis, all of the above options apply plus the launch window time and the order of landing sites desired for AOA and EOM.

4. Analysis of Runs and Time Conditional Probabilities. This analysis provides the capability of determining the Go or No-Go status for each day of the month for each year of the data sample. These are then analyzed to give the length of runs for both Go and No-Go, if a given day is No-Go, what is the probability of succeeding days being a Go; or, if a given day is Go, what is the probability of succeeding days being Go or No-Go.

III. ILLUSTRATIVE EXAMPLES

This section presents illustrative examples for the probability of atmospheric constraints for launch, return to launch site, and prelaunch for a March 0800 LST launch from the KSC. Another set of examples is given for the end of mission landing atmospheric constraints to illustrate the frequency of occurrence, runs probabilities, and time conditional probabilities.

A. Example for Launch, RTLS, and Prelaunch

These examples are for illustrative purpose only. They do not necessarily represent the atmospheric constraints for any particular orbiter configuration.

1. Probability of Atmospheric Constraints for KSC Launch Operations for March (Table 1.a). For this example, there are five assigned atmospheric constraints. The body of the table gives the percentage probability for the occurrence for each of the five constraints for each hour of the day versus local standard time. For brevity, this table is also called No-Go probabilities for launch operations. The Go probabilities in percent would be these values subtracted from 100 percent. There must be some rationale in the selection of the atmospheric constraints:

- 1) The thunderstorm constraint is set by the Space Shuttle program design requirement. The vehicle is not designed to be launched through a thunderstorm.
- 2) The precipitation constraint is an operational concern for ice/frost accumulation on the ET. There was also an early concern for rain erosion of the tiles during ascent.

3) The cloud ceiling and visibility constraint is an early range safety constraint established to meet the requirement for visual sighting in the first 1600 ft of flight by a camera located 5 miles from the launch complex.

4) The peak wind speed has been eliminated from this example by setting the value above the observed range of this variable; i.e., > 99 knots.

5) The upper winds constraint is an algorithm for the maximum dynamic pressure constraint. In this example, the 25-m/sec wind component in the 10- to 15-km altitude region is a head wind component relative to the monthly mean in-plane wind component for the flight azimuth of 59 degrees.

6) The tower clearance peak surface wind ≥ 20 knots from the south plus and minus 30 degrees and greater than 28.7 knots for all other wind directions has been established as a facilities design limit.

The last line in Table 1.a gives the percentage probability of No-Go for the occurrence of one or more of the above listed constraints. Note that the occurrences of the individual constraints are not mutually exclusively events. The sum of the probability of the individual constraints exceeds, in some cases, the last entry in this table.

2. Probability of Atmospheric Constraints for KSC Return to Launch Site (RTLS) for March
(Table 1.b). For this example, the selected atmospheric constraints are:

1) The occurrence of a thunderstorm.

2) The occurrence of precipitation.

3) A cloud ceiling ≤ 5000 ft and/or visibility < 8 n.mi.

4) There is a separate breakout for the visibility < 8 n.mi.

5) Cloud cover > 0.5 . A cloud ceiling is defined as the height at which 0.6 or more of the sky is obscured by clouds. The concern for cloud cover and visibility is the desire of the flight crew to be able to see the runway in the event of an RTLS.

6) For peak runway winds, a head wind > 20 knots and/or a tail wind > 20 knots is selected for an orbiter flight test. Note, from the heading of this table, both ends of the runway are used in this example; therefore, there is no tail wind occurrence.

7) The surface steady state crosswind has been eliminated from this example by setting the value > 99 knots.

8) The peak crosswind to the runway > 10 knots in this example was selected for an orbiter flight test.

The entry entitled "Any of the Above" is the probability of occurrence of one or more of the above constraints for the RTLS.

The last entry in Table 1.b, entitled "Any of the Above for Launch and RTLS," is the probability for No-Go if any one of the above listed constraints for launch and RTLS is considered as a No-Go condition.

Here it is noted, again, that these constraints are not mutually exclusive events.

3. Probability of Atmospheric Constraints for Prelaunch Operations for KSC for March (Table 1.1).

The only prelaunch constraint considered is the occurrence of precipitation at any time after the external tank (ET) loading until launch time. This is because there is concern that ice will form on the ET if precipitation occurs. The concern is that the ice will fall off during ascent and damage the orbiter tiles. In this example, there is a 15 percent chance that precipitation will occur at least one time between the hours of 0200 and 0800 LST. This gives an overall No-Go probability of 73 percent for an 0800 LST March launch for the stated atmospheric constraints for prelaunch, launch, and RTLS.

For the future prelaunch statistical analysis for Vandenberg Air Force Base, a different approach will be used for the ET ice constraint. A thermal transfer simulation has been made using the atmospheric variables for Vandenberg Air Force Base to determine the amount of ice accumulated for each hour of the day for various exposure periods. The prelaunch constraint for the ET ice will be made in terms of an ice thickness constraint. The assigned ice thickness will be treated in a statistical manner as any other atmospheric variable.

The examples given for No-Go probabilities in Tables 1.a through 1.c are intended for instructive purposes only. The assigned atmospheric constraints and their values are not to be construed as mission rules. The resulting probabilities are more accurately interpreted as the chances there will be concern for the operating restriction. For example, the launch mission rule may read no launch through a thunderstorm. The meteorological data base gives only the occurrence of thunderstorms and a thunderstorm is reported only when thunder is heard. Thunder is heard over a radius of approximately 10 miles. During operations, there is certainly a reason to be concerned when a thunderstorm is reported. Additional information is required, e.g., where is the thunderstorm in relation to the vehicle flight path, the time of the report, and expected thunderstorm movement.

The range safety requirement rule is for visual sighting of the flight in the first 1600 ft from a position 5 miles from the launch complex. A translation of this rule is made in terms of a cloud ceiling and visibility. The rationale for other atmospheric constraints is similarly interpretations of operating restrictions. Certainly, the statistics given in the mission analysis programs are the chance there will be concerns for the Shuttle operating restrictions as related to atmospheric conditions. Any number of atmospheric constraint limits and options to the computer programs can be exercised to make relative comparisons of various translations of operating restrictions in terms of the available atmospheric data bases.

B. KSC EOM Trade Study Examples

Two sets of atmospheric constraints for EOM landing at KSC are presented to illustrate a trade study analysis for mission planning. These two sets of atmospheric constraints are designated as Case I and Case II throughout the following discussion.

The Case I atmospheric constraints are:

- 1) Thunderstorm occurrence.
- 2) Precipitation occurrence.
- 3) Cloud ceiling \leq 20,000 ft and/or visibility less than 8 n.mi.

4) Runway winds: peak head wind > 25 knots. (Since both ends of the runway are used, there is no tail wind constraint.)

5) Peak cross runway wind > 10 knots.

The Case II atmospheric constraints are the same as Case I except steady state runway winds are used.

The Shuttle mission planning questions addressed are:

1) For two sets of atmospheric constraints for landing at KSC at the EOM, what is the probability each of the constraints occurring and for any one of the constraints occurring?

2) For the sets of constraints, what is the probability of EOM landing delays for N consecutive days at a specified time of day?

3) For the sets of constraints, what is the probability of N consecutive additional delay days, given that the EOM landing is delayed for J consecutive days?

Answers to these three questions are illustrated.

1. Probability of Atmospheric Constraints for EOM Landing at KSC, January and July. The percentage probability for No-Go for each of the Case I atmospheric constraints for EOM landing at KSC for each hour local standard time for January and July is presented in Tables 2 and 3. The ceiling and visibility constraint is the most frequent cause for No-Go for landing in January followed by the peak crosswind constraint. Whereas in July, the peak crosswind is the most frequent cause for No-Go for landing. Also, note the high frequency of thunderstorms in the afternoon hours in July. The last line in Tables 2 and 3 gives the probability of No-Go for landing caused by any one of the above listed constraints. A summary chart (Table 4) gives the probability for any one of the Case I atmospheric constraints for all months versus all hours. Here it is seen that the "best" landing times are early morning hours during the summer months and the "worst" times are near noon to midafternoon with 60 percent chance for No-Go for landing in all months except November and December.

To contrast the No-Go probability for the Case I atmospheric constraints presented in Tables 2, 3, and 4, similar tables for the Case II atmospheric constraints are presented as Tables 5, 6, and 7. Here, the contribution to the No-Go probabilities caused by the peak runway wind constraint is noted. All other constraints are the same. From Table 7 there is a 20 to 55 percent chance for No-Go for landing due to one or more of the stated atmospheric constraints.

2. Runs and Time Conditional Probabilities. Tables 8, 9, and 10 are presented to illustrate the techniques for the analysis of runs and conditional probabilities for the Case I atmospheric constraints for the EOM landing at KSC at 0900 hr LST in January.

In Table 8, the entries are consecutive listings of codes "0" for Go and "1" for No-Go for each January day for the 14 years of records. This table gives the No-Go days and Go days for landing for the Case I atmospheric constraints at 0900 hr LST at KSC when any one of the five constraints occurred or did not occur for the 434 days. It is from a listing of Go and No-Go days (Table 8) that Tables 9 and 10 are derived.

A run is a succession of like events or things. An explanation of the computational procedures used to derive Tables 9 and 10 from Table 8 is in order because of the unusual techniques used to count runs and overlapping runs. To illustrate, let there be a sequence, as:

aaa, bb, aaaa, b, aaaaaa, bbbb

There are four runs of a's and three runs of b's. There is one run of a's of length 1, no runs of a's of length 2, two runs of a's of length 3, and one run of a's of length 5. There are three runs of a's of length 3 or more, one run of length 4 or more, and one run of length 5. There are, by counting all possible overlapping lengths of runs, twelve runs of a's of length 1 (i.e., there are twelve a's in the sequence), there are eight runs of length 2, five runs of length 3, two runs of length 4, and one run of length 5.

The computational format for the above counting of runs can be conveniently arranged as in the following:

Illustration for Counting Runs

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Length of Run, N_i	Number of Runs of a's of Length N_i	First Sum	Second Sum	Prob. of a Run of a of Length N_i	Number of Runs of b's of Length N_i	First Sum	Second Sum	Prob. of a Run of b of Length N_i
1	1	4	12	0.63	1	3	7	0.36
2	0	3	8	0.42	1	2	4	0.21
3	2	3	6	0.26	0	1	2	0.11
4	0	1	2	0.11	1	1	1	0.06
5	1	1	1	0.06	—			

$12 + 7 = 19 = N_T$, the number of observations in the sequence.

Now, turning to Table 9, the first column gives the length of run for No-Go for the stated atmospheric constraints. The second column gives the observed number (frequency) of runs of length N , the first column. For example, there was one run of length 13 and there were no runs of length 12. These frequencies are obtained by counting the lengths of runs of 1's in Table 8. In Table 8, there are 14 sequences of length 31. A run is not continued from one January year to another. The fifth column, heading Probability Percent of No-Go Days, gives the probability there will be No-Go conditions for N consecutive days for the Case I atmospheric constraints for the EOM landing at 0900 LST. For example, there is a 58 percent chance of No-Go for landing at 0900 LST at KSC in January. This is the same probability obtained from the previous computer program for Table 2. There is a 38 percent chance for No-Go landing on two consecutive days at 0900 LST and there is a 13 percent chance for No-Go landing for five consecutive days.

The array of probabilities (Table 9) under the headings $J=1$, $J=2$, etc., are the time conditional probabilities. These probabilities are obtained by dividing the N_{i+j} values by N_j in column 4, the second sum column, e.g.,

For $J=1$, $(163/253) 100 = 64$ percent , $(112/253) 100 = 47$ percent , etc.

and for

$J=2$, $(112/163) 100 = 69$ percent , $(76/163) 100 = 47$ percent , etc.

The application of these conditional probabilities is illustrated. Suppose the Shuttle Orbiter is in orbit in January and scheduled to land at KSC at 0900 LST and the Case I atmospheric constraints exist. Now it is a certainty, a probability of 100 percent, there is no landing today; then there is a 64 percent chance (read under the $J=1$ column) that there will be no landing tomorrow at 0900 LST; and a 44 percent chance for no landing for the day after tomorrow at 0900 LST. Now let it be given that there was no landing yesterday and no landing today due to the Case I atmospheric constraints; then there is a 69 percent chance (read under column $J=2$) there will be no landing tomorrow at 0900 LST.

Table 10 gives the runs and conditional probabilities for favorable conditions for the KSC EOM landing at 0900 LST for the Class I atmospheric constraints. For example, reading from the fifth column in Table 10, there is a 42 percent chance for landing at 0900 LST in January; there is a 21 percent chance for landing at 0900 LST on two consecutive days, etc. Given that it is favorable for landing today, then there is a 50 percent chance (read under $J=1$) that the Case I atmospheric constraints will be favorable for landing tomorrow, etc.

The runs and conditional probabilities contained in Tables 1 and 2 are illustrated in Figures 1 and 2. Further, for the Case I, atmospheric constraints for the EOM landing at KSC at 0900 LST for July are shown in Figures 3 and 4. The straight line labeled $P(N)$ in the figures give the probability for the length of runs for independent events. If the observed probabilities for run lengths were independent from day to day, then there would be close agreement between the observed runs probabilities (labeled with triangles) and the $P(N)$ curve. Further, the observed conditional probabilities would be coincident to the $P(N)$ curve shifted by each unit for $J=1$, $J=2$, etc. There is definitely persistence in the Case I atmospheric constraints because there are observed longer runs that would be the case for independent events.

Figures 5, 6, 7, and 8 are the illustrations for the runs and conditional probabilities for the Case II atmospheric constraints for the No-Go and Go statistics for a KSC EOM landing at 0900 LST. In these examples, the observed probability for the run length appears sufficiently close to the $P(N)$ curve to be considered as independent events. However, the rule for independent event does not appear in agreement for the conditional probabilities. Three simple theoretical structures may be considered; viz.

- 1) The probability of the events is constant from day to day.
- 2) The probability of the events is constant after 1 or 2 days.
- 3) The probability of the events is continually increasing from day to day.

Because the run probabilities are so highly dependent on the assigned atmospheric constraints, season, and time of day, there is little hope that a general probability law could apply. Hence, the recommended approach is to use the observed (empirical) probabilities for runs and conditional probabilities.

The application of these statistics to the Space Shuttle operations lies in developing planning strategies. For example, the decision strategy for the EOM landing for the assigned atmospheric constraints would be to prepare for continuation in orbit for several days if unfavorable landing conditions exist. If favorable

landing conditions exist at the EOM, proceed to land at the earliest opportunity. Another strategy is to prepare for an alternative landing site to decrease the risk of landing under unfavorable atmospheric conditions. It is in this planning of operating strategies that there is value in the statistical analysis of runs and conditional probabilities.

The techniques used to count runs and the computation of conditional probabilities were first introduced for space vehicle applications by O. E. Smith in 1961 and used subsequently by other investigators [2,3] in the analysis of atmospheric data. The technique has proven useful and valid for related applications.

IV. CONCLUSIONS/RECOMMENDATIONS

A capability to furnish in a timely manner specific atmospheric constraint statistics for the Space Shuttle mission phases for management decisions in mission planning and trade studies has been demonstrated. A few examples of the many options for the computer programs have been presented to illustrate the statistical methods. The locations covered by the present capability are for the KSC launch site and for the Edwards Air Force Base and Northrup Strip landing sites. Work is in progress to include the Vandenberg Air Force Base launch site in the mission analysis programs. Additional landing sites, for example AOA sites for Vandenberg Air Force Base launches, and down range abort and landing sites for which there are standard atmospheric data available could be included in the mission analysis programs if the demand develops for these extensions. Further, if the demand develops for more efficient decision aids, then formal decision strategy computer programs could be developed.

A distinction is made between the Space Shuttle operating rules as related to meteorological variables and atmospheric constraints. The atmospheric constraints are translations or interpretations of the Shuttle operating rules so that the probability of occurrence and nonoccurrence of these atmospheric constraints can be obtained from standard historical meteorological data as is available from the national weather services.

It is recommended that the Space Shuttle launch and flight operational rules for atmospheric restrictions be continually reviewed for rule changes. As these rule changes develop, they can be translated into atmospheric constraints and updates for the mission analysis statistics can be performed.

TABLE 1.a. PROBABILITY OF ATMOSPHERIC CONSTRAINTS FOR KSC LAUNCH OPERATIONS FOR MARCH

KSC		LAUNCH OPERATIONS FOR THE MONTH OF MAR																								1
KUNCAVE 3-16-82 TIME 20:56:21																										
PERIOD: RECORD 1957 - 1970																										
DATA SOURCES:																										
CLOCK IN																										
SERIALLY COMPLETE																										
THUNDERSTORM																										
PEAK WINDS																										
CONSTRAINT/REQUIREMENT		HR	HR	HR	HR	HR	HR	HR	HR	HR	HR	HR	HR	HR	HR	HR	HR	HR	HR	HR	HR	HR	HR	HR	HR	HR
		00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	
THUNDERSTORM		1	1	1	1	0	1	1	1	1	0	1	1	1	2	2	2	2	2	2	3	2	2	3	1	
PRECIPITATION		7	9	7	7	6	6	6	4	6	6	3	6	6	6	6	6	6	6	7	9	10	8	7	6	
CLOUD CEILING																										
COP = 1600 FT																										
AND OR VISIBILITY																										
C S. N. MILES		5	5	6	6	7	8	10	13	11	9	8	5	4	4	4	5	4	5	4	4	3	4	4	4	
PEAK SURFACE WS																										
> 99 KNOTS		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
UPPER WINDS																										
AT MAX G 10-15 KM																										
AZIMUTH = 50°																										
U > 25.0 M/S		3	3	3	2	2	2	2	3	3	3	3	3	4	3	3	3	3	3	3	3	3	3	3	3	
TOWER CLEARANCE																										
PEAK SURFACE WS																										
> 20.0 KNOTS																										
AT 150-210.0 DEG. W																										
> 20.7 KNOTS		3	3	3	3	3	3	3	4	4	6	6	9	9	8	10	9	10	6	4	4	3	3	2	3	
AT ALL OTHER WD																										
ANY OF THE ABOVE		14	16	17	15	15	17	19	20	19	21	20	21	20	18	20	19	21	17	16	18	17	14	13	14	

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TABLE 1.b. PROBABILITY OF ATMOSPHERIC CONSTRAINTS FOR KSC RETURN TO LAUNCH SITE FOR MARCH

KSC		RETURN TO LAUNCH SITE FOR THE MONTH OF MAR		PAGE 1																					
RUN DATE 3-16-82 TIME 20:16:21																									
PERIOD OF RECORD 1957 - 1970																									
DATA SOURCES :																									
CSCM IN																									
SEVERITY COMPLETE																									
THUNDERSTORM																									
PEAK WINDS																									
RUNWAY ANGLE 155.0 AND 335.0 DEGREES																									
CONSTRAINT/EQUIPMENT		PROBABILITIES IN PERCENT																							
HR	HR	HR	HR	HR	HR	HR	HR	HR	HR	HR	HR	HR	HR	HR	HR	HR	HR	HR	HR	HR	HR	HR	HR	HR	HR
00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1	1	1	1	0	1	1	1	0	1	1	1	2	2	2	2	2	2	2	2	3	2	2	3	1	
7	9	7	7	6	6	6	4	6	5	6	6	5	6	6	6	6	6	6	7	9	10	8	7	6	
18	21	24	24	27	26	28	27	24	22	20	20	20	20	22	20	19	17	17	18	17	18	17	18	18	
CLOUD CEILING																									
< 500 FT																									
AND OR VISIBILITY																									
< 8.0 MILES																									
VISIBILITY																									
< 8.0 MILES	9	12	12	13	16	15	16	18	12	10	8	7	7	8	7	6	6	7	9	8	8	7	7	7	
CLOUD COVER																									
> 25	45	47	47	48	48	44	52	56	57	58	56	54	55	58	58	56	56	58	59	53	47	47	47	44	
PEAK WINDS																									
HEAD WIND > 20 KNOTS																									
TAIL WIND > 20 KNOTS	3	3	5	6	5	4	3	5	7	10	10	12	15	13	13	15	13	10	6	4	5	5	3	3	
SURFACE CROSSWIND																									
> 99 KNOTS-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
PEAK CROSSWIND																									
> 10 KNOTS-	23	19	16	16	17	16	18	15	25	29	33	33	39	43	47	45	44	15	27	21	22	22	23	22	
ANY OF THE ABOVE		60	59	58	60	61	59	65	69	72	74	76	74	77	81	84	82	81	78	73	64	59	60	61	59

ANY OF THE ABOVE FOR LAUNCH AND PTL		61	60	59	61	61	60	66	70	72	75	76	75	76	81	85	82	81	78	73	64	60	61	61	59

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TABLE 1.0. PROBABILITY OF ATMOSPHERIC CONSTRAINTS FOR PRELAUNCH OPERATIONS FOR KSC FOR MARCH

KSC PRELAUNCH OPERATION FOR MONTH OF MAR													
PERIOD OF RECORD 1957-1970													
CONSTRAINT/EQUIPMENT													
PROBABILITIES IN PERCENT													
02	03	04	05	06	07	08	COMBINED HRS						
2 - 8													
PRECIPITATION													
7	7	6	6	4	4	6	15						
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TABLE 2. PROBABILITY OF CASE I ATMOSPHERIC CONSTRAINTS FOR EOM LANDING AT KSC, JANUARY

KSC		RETURN TO LAUNCH SITE FOR THE MONTH OF JAN												PAGE 1	
RUNDATE 4-17-82 TIME 21:16: 8															
PERIOD OF RECORD 1957 - 1970															
DATA SOURCES :															
DECP 144															
SERIALLY COMPLETE															
THUNDERSTORM															
PEAK WINDS															
RUNWAY ANGLE 155.0 AND 335.0 DEGREES															
PROBABILITIES IN PERCENT															
CONSTRAINT/REQUIREMENT		HR	HR	HR	HR	HR	HR	HR	HR	HR	HR	HR	HR	HR	HR
		DC	01	02	03	04	05	06	07	08	09	10	11	12	13
		14	15	16	17	18	19	20	21	22	23	24	25	26	27
		28	29	30	31	32	33	34	35	36	37	38	39	40	41
		42	43	44	45	46	47	48	49	50	51	52	53	54	55
		56	57	58	59	60	61	62	63	64	65	66	67	68	69
		70	71	72	73	74	75	76	77	78	79	80	81	82	83
		84	85	86	87	88	89	90	91	92	93	94	95	96	97
		98	99	00	01	02	03	04	05	06	07	08	09	10	11
		12	13	14	15	16	17	18	19	20	21	22	23	24	25
		26	27	28	29	30	31	32	33	34	35	36	37	38	39
		40	41	42	43	44	45	46	47	48	49	50	51	52	53
		54	55	56	57	58	59	60	61	62	63	64	65	66	67
		68	69	70	71	72	73	74	75	76	77	78	79	80	81
		82	83	84	85	86	87	88	89	90	91	92	93	94	95
		96	97	98	99	00	01	02	03	04	05	06	07	08	09
		10	11	12	13	14	15	16	17	18	19	20	21	22	23
		24	25	26	27	28	29	30	31	32	33	34	35	36	37
		38	39	40	41	42	43	44	45	46	47	48	49	50	51
		52	53	54	55	56	57	58	59	60	61	62	63	64	65
		66	67	68	69	70	71	72	73	74	75	76	77	78	79
		80	81	82	83	84	85	86	87	88	89	90	91	92	93
		94	95	96	97	98	99	00	01	02	03	04	05	06	07
		08	09	10	11	12	13	14	15	16	17	18	19	20	21
		22	23	24	25	26	27	28	29	30	31	32	33	34	35
		36	37	38	39	40	41	42	43	44	45	46	47	48	49
		50	51	52	53	54	55	56	57	58	59	60	61	62	63
		64	65	66	67	68	69	70	71	72	73	74	75	76	77
		78	79	80	81	82	83	84	85	86	87	88	89	90	91
		92	93	94	95	96	97	98	99	00	01	02	03	04	05
		06	07	08	09	10	11	12	13	14	15	16	17	18	19
		20	21	22	23	24	25	26	27	28	29	30	31	32	33
		34	35	36	37	38	39	40	41	42	43	44	45	46	47
		48	49	50	51	52	53	54	55	56	57	58	59	60	61
		62	63	64	65	66	67	68	69	70	71	72	73	74	75
		76	77	78	79	80	81	82	83	84	85	86	87	88	89
		90	91	92	93	94	95	96	97	98	99	00	01	02	03
		04	05	06	07	08	09	10	11	12	13	14	15	16	17
		18	19	20	21	22	23	24	25	26	27	28	29	30	31
		32	33	34	35	36	37	38	39	40	41	42	43	44	45
		46	47	48	49	50	51	52	53	54	55	56	57	58	59
		60	61	62	63	64	65	66	67	68	69	70	71	72	73
		74	75	76	77	78	79	80	81	82	83	84	85	86	87
		88	89	90	91	92	93	94	95	96	97	98	99	00	01
		02	03	04	05	06	07	08	09	10	11	12	13	14	15
		16	17	18	19	20	21	22	23	24	25	26	27	28	29
		30	31	32	33	34	35	36	37	38	39	40	41	42	43
		44	45	46	47	48	49	50	51	52	53	54	55	56	57
		58	59	60	61	62	63	64	65	66	67	68	69	70	71
		72	73	74	75	76	77	78	79	80	81	82	83	84	85
		86	87	88	89	90	91	92	93	94	95	96	97	98	99
		00	01	02	03	04	05	06	07	08	09	10	11	12	13
		14	15	16	17	18	19	20	21	22	23	24	25	26	27
		28	29	30	31	32	33	34	35	36	37	38	39	40	41
		42	43	44	45	46	47	48	49	50	51	52	53	54	55
		56	57	58	59	60	61	62	63	64	65	66	67	68	69
		70	71	72	73	74	75	76	77	78	79	80	81	82	83
		84	85	86	87	88	89	90	91	92	93	94	95	96	97
		98	99	00	01	02	03	04	05	06	07	08	09	10	11
		12	13	14	15	16	17	18	19	20	21	22	23	24	25
		26	27	28	29	30	31	32	33	34	35	36	37	38	39
		40	41	42	43	44	45	46	47	48	49	50	51	52	53
		54	55	56	57	58	59	60	61	62	63	64	65	66	67
		68	69	70	71	72	73	74	75	76	77	78	79	80	81
		82	83	84	85	86	87	88	89	90	91	92	93	94	95
		96	97	98	99	00	01	02	03	04	05	06	07	08	09
		10	11	12	13	14	15	16	17	18	19	20	21	22	23
		24	25	26	27	28	29	30	31	32	33	34	35	36	37
		38	39	40	41	42	43	44	45	46	47	48	49	50	51
		52	53	54	55	56	57	58	59	60	61	62	63	64	65
		66	67	68	69	70	71	72	73	74	75	76	77	78	79
		80	81	82	83	84	85	86	87	88	89	90	91	92	93
		94	95	96	97	98	99	00	01	02	03	04	05	06	07
		08	09	10	11	12	13	14	15	16	17	18	19	20	21
		22	23	24	25	26	27	28	29	30	31	32	33	34	35
		36	37	38	39	40	41	42	43	44	45	46	47	48	49
		50	51	52	53	54	55	56	57	58	59	60	61	62	63
		64	65	66	67	68	69	70	71	72	73	74	75	76	77
		78	79	80	81	82	83	84	85	86	87	88	89	90	91
		92	93	94	95	96	97	98	99	00	01	02	03	04	05
		06	07	08	09	10	11	12	13	14	15	16	17	18	19
		20	21	22	23	24	25	26	27	28	29	30	31	32	33
		34	35	36	37	38	39	40	41	42	43	44	45	46	47
		48	49	50	51	52	53	54	55	56	57	58	59	60	61
		62	63	64	65	66	67	68	69	70	71	72	73	74	75
		76	77	78	79	80	81	82	83	84	85	86	87	88	89
		90	91	92	93	94	95	96	97	98	99	00	01	02	03
		04	05	06	07	08	09	10	11	12	13	14	15	16	17
		18	19	20	21	22	23	24	25	26	27	28	29	30	31
		32	33	34	35	36	37	38	39	40	41	42	43	44	45
		46	47	48	49	50	51	52	53	54	55	56	57	58	59
		60	61	62	63	64	65	66	67	68	69	70	71	72	73
		74	75	76	77	78	79	80	81	82	83	84	85	86	87
		88	89	90	91	92	93	94	95	96	97	98	99	00	01
		02	03	04	05	06	07	08	09	10	11	12	13	14	15
		16	17	18	19	20	21	22	23	24	25	26	27	28	29
		30	31	32	33	34	35	36	37	38	39	40	41	42	43
		44	45	46	47	48	49	50	51	52	53	54	55	56	57
		58	59	60	61	62	63	64	65	66	67	68	69	70	71
		72	73	74	75	76	77	78	79	80	81	82	83	84	85
		86	87	88	89	90	91	92	93	94	95	96	97	98	99
		00	01	02	03	04	05	06	07	08	09	10	11	12	13
		14	15	16	17	18	19	20	21	22	23	24	25	26	27
		28	29	30	31	32	33	34	35	36	37	38	39	40	41
		42	43	44	45	46	47	48	49	50	51	52	53	54	55
		56	57	58	59	60	61	62	63	64	65	66	67	68	69
		70	71	72	73	74	75	76	77	78	79	80	81	82	83
		84	85	86	87	88	89	90	91	92	93	94	95	96	97
		98	99	00	01	02	03	04	05	06	07	08	09	10	11
		12	13	14	15	16	17	18	19	20	21	22	23	24	25
		26	27	28	29	30	31	32	33	34	35	36	37	38	39
		40	41	42	43	44	4								

TABLE 3. PROBABILITY OF CASE I ATMOSPHERIC CONSTRAINTS FOR EOM LANDING AT KSC, JULY

KSC		RETURN TO LAUNCH SITE FOR THE MONTH OF JUL																								PAGE 1
RUNDATL 4-13-82 TIME 21:20:10																										
PERIOD OF RECORD 1957 - 1970																										
DATA SOURCES :																										
DECK 144																										
SPECIALLY COMPLETE																										
THUNDERSTORM																										
PEAK WINDS																										
RUNWAY ANGLE 155.0 AND 335.0 DEGREES																										
CONSTRAINT/REQUIREMENT		PROBABILITIES IN PERCENT																								
THUNDERSTORM		MR	MR	MR	MR	MR	MR	MR	MR	MR	MR	MR	MR	MR	MR	MR	MR	MR	MR	MR	MR	MR	MR	MR	MR	
		00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	
		3	3	3	2	3	3	3	3	3	2	3	5	9	15	19	24	27	24	21	14	9	8	6	5	
PRECIPITATION		3	1	1	1	1	2	2	2	1	1	2	3	4	6	8	8	11	12	14	10	8	6	3	3	
CLOUD CEILING		15	18	16	17	15	18	21	21	20	18	20	19	21	19	24	25	27	31	33	32	29	22	18	17	
< OR = 2000 FT		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
AND OF VISIBILITY		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
< 8. N. MILES		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
VISIBILITY		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
< 0. N. MILES		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
CLOUD COVER		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
> 9.9		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
PEAK WINDS		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
HEAD WIND > 25 KNOTS		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
TAIL WIND > 10 KNOTS		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
SURFACE CROSSWIND		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
> 99 KNOTS-		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
PEAK CROSSWIND		5	4	4	5	4	3	3	11	17	22	23	25	32	37	41	38	35	24	21	9	6	4	4	4	
> 10 KNOTS-		21	23	21	23	19	21	24	30	34	38	40	47	52	61	63	63	57	53	41	35	27	24	23	23	
ANY OF THE ABOVE		21	23	21	23	19	21	24	30	34	38	40	47	52	61	63	63	57	53	41	35	27	24	23	23	
ANY OF THE ABOVE FOR LAUNCH AND RTLS		21	23	21	23	19	21	24	30	34	38	40	47	52	61	63	63	57	53	41	35	27	24	23	23	
		MR	MR	MR	MR	MR	MR	MR	MR	MR	MR	MR	MR	MR	MR	MR	MR	MR	MR	MR	MR	MR	MR	MR	MR	
		00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	
ANY OF THE ABOVE FOR LAUNCH, RTLS, AND PRELAUNCH		21	23	21	23	19	21	24	30	34	38	40	47	52	61	63	63	57	53	41	35	27	24	23	23	

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TABLE 4. PROBABILITY OF NO-GO FOR ANY ONE OF CASE 1 ATMOSPHERIC CONSTRAINTS FOR EOM LANDING AT KSC FOR ALL MONTHS

CUMULATE 4-13-62 TIME 21:24:11

Case I

ASC ANY OF THE ABOVE FOR EOM

Hour LST

[illegible]

	50%	60%	70%	80%	90%	100%
JAN	47 53 50 51 54 57 56 62 59 61 62 58 59 57 54 55 46 44 41 45 44 46 45					
FEB	46 48 50 51 54 56 55 62 60 58 61 61 63 64 62 58 52 46 46 48 47 48 48					
MAR	47 45 45 46 49 50 54 53 56 57 61 55 59 65 67 65 63 59 52 47 46 47 47 47					+10%
APR	42 43 42 41 41 40 45 47 52 54 53 58 64 63 65 66 63 55 46 40 36 38 39 39	40%				
MAY	34 32 33 32 31 36 30 43 47 50 56 58 64 69 70 72 70 63 52 42 36 36 37 35	30%	70%			30%
JUN	28 27 31 30 29 31 37 40 45 47 51 59 67 78 75 75 73 65 57 50 44 39 32 28					
JUL	21 23 21 23 19 21 24 30 34 38 40 47 52 61 63 63 57 53 41 35 27 24 23					
AUG	21 21 19 20 21 26 26 29 32 36 40 46 52 59 64 63 56 46 36 29 29 23 23 30%	30%	70%			
SEP	42 40 36 37 37 35 41 44 45 51 57 61 67 69 71 75 70 65 53 51 50 47 44 40 40%					
OCT	47 48 50 49 48 48 50 53 52 55 58 60 62 66 66 63 60 57 51 53 50 48 49 47					
NOV	42 42 43 42 46 46 45 52 51 53 53 54 55 54 55 53 48 42 41 40 40 41 41 40					-10%
DEC	44 45 45 44 43 49 52 52 49 51 52 54 55 51 49 46 40 36 37 35 40 41 40					-10%

Constraints:

1. Thunderstorms
2. Precipitation
3. Ceiling \leq 20,000 feet or visibility $<$ 8 nautical miles - a major factor winter AM
4. Peak head wind $>$ 25 knots; peak tail wind no factor because both ends of runway are used.
5. Peak crosswind $>$ 10 knots - a major factor in PM

TABLE 5. PROBABILITY OF CASE II ATMOSPHERIC CONSTRAINTS FOR EOM LANDING AT KSC, JANUARY

RURDATE 9-30-62 TIME 1911456		KSC RETURN TO LAUNCH SITE FOR THE MONTH OF JAN		PAGE 1	
PERIOD OF RECORD 1957 - 1970					
DATA SOURCES :					
FECALIN					
SERIALLY COMPLETE					
THUNDERSTORM					
PEAK WINDS					
BUYWAY ANGLE 155.0 AND 335.0 DEGREES		PROBABILITIES IN PERCENT			
		MR	MR	MR	MR
		00	01	02	03
		04	05	06	07
		08	09	10	11
		12	13	14	15
		16	17	18	19
		20	21	22	23
CONSTRAINT/EQUIPMENT		00	01	02	03
		04	05	06	07
		08	09	10	11
		12	13	14	15
		16	17	18	19
		20	21	22	23
THUNDERSTORM		00	01	02	03
		04	05	06	07
		08	09	10	11
		12	13	14	15
		16	17	18	19
		20	21	22	23
PRECIPITATION		00	01	02	03
		04	05	06	07
		08	09	10	11
		12	13	14	15
		16	17	18	19
		20	21	22	23
CLOUD CEILING		00	01	02	03
		04	05	06	07
		08	09	10	11
		12	13	14	15
		16	17	18	19
		20	21	22	23
AND/OR VISIBILITY		00	01	02	03
		04	05	06	07
		08	09	10	11
		12	13	14	15
		16	17	18	19
		20	21	22	23
VISIBILITY		00	01	02	03
		04	05	06	07
		08	09	10	11
		12	13	14	15
		16	17	18	19
		20	21	22	23
CLOUD COVER		00	01	02	03
		04	05	06	07
		08	09	10	11
		12	13	14	15
		16	17	18	19
		20	21	22	23
STEADY WINDS		00	01	02	03
		04	05	06	07
		08	09	10	11
		12	13	14	15
		16	17	18	19
		20	21	22	23
HEAD WIND > 25 KNOTS		00	01	02	03
		04	05	06	07
		08	09	10	11
		12	13	14	15
		16	17	18	19
		20	21	22	23
TAIL WIND > 15 KNOTS		00	01	02	03
		04	05	06	07
		08	09	10	11
		12	13	14	15
		16	17	18	19
		20	21	22	23
SURFACE CROSSWIND		00	01	02	03
		04	05	06	07
		08	09	10	11
		12	13	14	15
		16	17	18	19
		20	21	22	23
> 10 KNOTS-		00	01	02	03
		04	05	06	07
		08	09	10	11
		12	13	14	15
		16	17	18	19
		20	21	22	23
PEAK CROSSWIND		00	01	02	03
		04	05	06	07
		08	09	10	11
		12	13	14	15
		16	17	18	19
		20	21	22	23
> 99 KNOTS-		00	01	02	03
		04	05	06	07
		08	09	10	11
		12	13	14	15
		16	17	18	19
		20	21	22	23
ANY OF THE ABOVE		00	01	02	03
		04	05	06	07
		08	09	10	11
		12	13	14	15
		16	17	18	19
		20	21	22	23
ANY OF THE ABOVE FOR		00	01	02	03
		04	05	06	07
		08	09	10	11
		12	13	14	15
		16	17	18	19
		20	21	22	23
LAUNCH AND "TLS"		00	01	02	03
		04	05	06	07
		08	09	10	11
		12	13	14	15
		16	17	18	19
		20	21	22	23
ANY OF THE ABOVE FOR		00	01	02	03
		04	05	06	07
		08	09	10	11
		12	13	14	15
		16	17	18	19
		20	21	22	23
LAUNCH, RTLS, AND PRELAUNCH		00	01	02	03
		04	05	06	07
		08	09	10	11
		12	13	14	15
		16	17	18	19
		20	21	22	23

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TABLE 6. PROBABILITY OF CASE II ATMOSPHERIC CONSTRAINTS FOR EOM LANDING AT KSC, JULY

PUNCATL 9-14-82 TIME 19:17:32		KSC RETURN TO LAUNCH SITE FOR THE MONTH OF JUL		PAGE 1	
PERIOD OF RECORD 1957 - 1970					
DATA SOURCES :					
GIC4 184					
SERIALLY COMPLETE					
THUNDERSTORM					
PEAK WINDS					
RUNWAY ANGLE 155.0 AND 335.0 DEGREES					
		PROBABILITIES IN PERCENT			
CONSTRAINT/REQUIREMENT	MR	MR	MR	MR	MR
	00	01	02	03	04
	05	06	07	08	09
	10	11	12	13	14
	15	16	17	18	19
	20	21	22	23	24
	25	26	27	28	29
	30	31	32	33	34
	35	36	37	38	39
	40	41	42	43	44
	45	46	47	48	49
	50	51	52	53	54
	55	56	57	58	59
	60	61	62	63	64
	65	66	67	68	69
	70	71	72	73	74
	75	76	77	78	79
	80	81	82	83	84
	85	86	87	88	89
	90	91	92	93	94
	95	96	97	98	99
	00	01	02	03	04
	05	06	07	08	09
	10	11	12	13	14
	15	16	17	18	19
	20	21	22	23	24
	25	26	27	28	29
	30	31	32	33	34
	35	36	37	38	39
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	45	46	47	48	49
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	55	56	57	58	59
	60	61	62	63	64
	65	66	67	68	69
	70	71	72	73	74
	75	76	77	78	79
	80	81	82	83	84
	85	86	87	88	89
	90	91	92	93	94
	95	96	97	98	99
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	05	06	07	08	09
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	35	36	37	38	39
	40	41	42	43	44
	45	46	47	48	49
	50	51	52	53	54
	55	56	57	58	59
	60	61	62	63	64
	65	66	67	68	69
	70	71	72	73	74
	75	76	77	78	79
	80	81	82	83	84
	85	86	87	88	89
	90	91	92	93	94
	95	96	97	98	99
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	95	96	97	98	99
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	90	91	92	93	94
	95	96	97	98	99
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	65	66	67	68	69
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	80	81	82	83	84
	85	86	87	88	89
	90	91	92	93	94
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	50	51	52	53	54
	55	56	57	58	59
	60	61	62	63	64
	65	66	67	68	69
	70	71	72	73	74
	75	76	77	78	79
	80	81	82	83	84
	85	86	87	88	89
	90	91	92	93	94
	95	96			

TABLE 7. PROBABILITY OF CASE II, ANY ONE OF ATMOSPHERIC CONSTRAINTS FOR EOM LANDING AT KSC FOR ALL MONTHS

[illegible]

Constraints:

1. Thunderstorms
2. Precipitation
3. Ceiling \leq 20,000 feet and/or visibility $<$ 8 nautical miles
4. Steady state head wind $>$ 25 knots; both ends of runway used, no tail wind constraint.
5. Steady state crosswind $>$ 10 knots

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TABLE 8. NO-GO AND GO FOR CASE I ATMOSPHERIC CONSTRAINTS FOR KSC EOM
LANDING AT 0900 LST, JANUARY

KSC LST, PRELAUNCH, LAUNCH, AND RTL'S																															
1 = NO/GO 0 = GO * = MISSING	DATE OF RUN 0-15-82 TIME 19110159																														
	MONTH = 1, HOUR = 9																														
	DAY																														
YEAR	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
1957	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1958	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1959	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1960	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1961	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1962	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1963	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1964	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1965	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1966	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1967	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1968	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1969	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1970	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

TABLE 9. PROBABILITY OF NO-GO RUNS AND CONDITIONAL PROBABILITIES FOR ANY ONE OF CASE I
ATMOSPHERIC CONSTRAINTS FOR KSC EOM LANDING AT 0900 LST, JANUARY

KSC LST, PRELAUNCH, LUNCH, AND RTLS

DATE OF RUN		4-15-92	TIME	19:10:59	MONTH = 1 HOUR = 7											
LENGTH OF RUN	FASC. OF RUN	PROB. 3 CF NO/GO														
		SUP	SUM	7	DAYS	J-1	J-2	J-3	J-4	J-5	J-6	J-7	J-8	J-9	J-10	
1	39	90	253	58	58	100	7	0	7	0	0	0	0	0	0	0
2	15	51	163	38	38	64	177	0	7	0	0	0	0	0	0	0
3	16	56	112	26	26	44	69	100	0	0	0	0	0	0	0	0
4	3	23	76	18	18	30	47	68	100	0	0	0	0	0	0	0
5	7	17	56	17	17	22	34	50	74	100	0	0	0	0	0	0
6	7	10	39	9	9	15	24	35	51	70	100	0	0	0	0	0
7	2	10	27	7	7	11	18	26	38	52	74	100	0	0	0	0
8	4	8	19	4	4	4	17	17	25	34	49	66	100	0	0	0
9	1	4	11	3	3	4	7	10	14	20	28	38	52	100	0	0
10	1	3	7	2	2	3	4	6	8	13	18	24	37	64	100	0
11	1	2	4	1	1	2	3	4	5	7	10	14	21	36	57	0
12	0	1	2	1	1	1	1	2	3	4	5	7	11	15	29	0
13	1	1	1	0	0	0	1	1	1	2	3	3	5	9	14	0

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TABLE 10. PROBABILITY OF GO RUNS AND CONDITIONAL PROBABILITIES FOR ANY ONE OF CASE I
ATMOSPHERIC CONSTRAINTS FOR KSC EOM LANDING AT 0900 LST, JANUARY

KSC LST, PRELAUNCH, LAUNCH, AND RTL																
DATE OF RUN		4-15-92		TIME		19:10:59		MONTH = 1 HOUR = 9								
LENGTH OF RUN	PREC. OF RUN	PROB. %		OF 50												
		LST	SUP	SUM	2	DAYS	J-1	J-2	J-3	J-4	J-5	J-6	J-7	J-8	J-9	J-10
1	45	90	191	42	107	7	7	0	3	3	0	0	0	0	3	0
2	24	45	51	21	50	100	0	0	0	0	0	0	0	0	0	0
3	15	25	56	11	25	51	100	0	0	0	0	0	0	0	0	0
4	2	10	21	5	17	24	46	100	0	0	0	0	0	0	0	0
5	5	9	11	3	6	32	24	52	100	0	0	0	0	0	0	0
6	1	2	3	1	2	3	7	14	27	100	0	0	0	0	0	0
7	1	1	1	7	1	1	1	2	5	33	100	0	0	0	0	0

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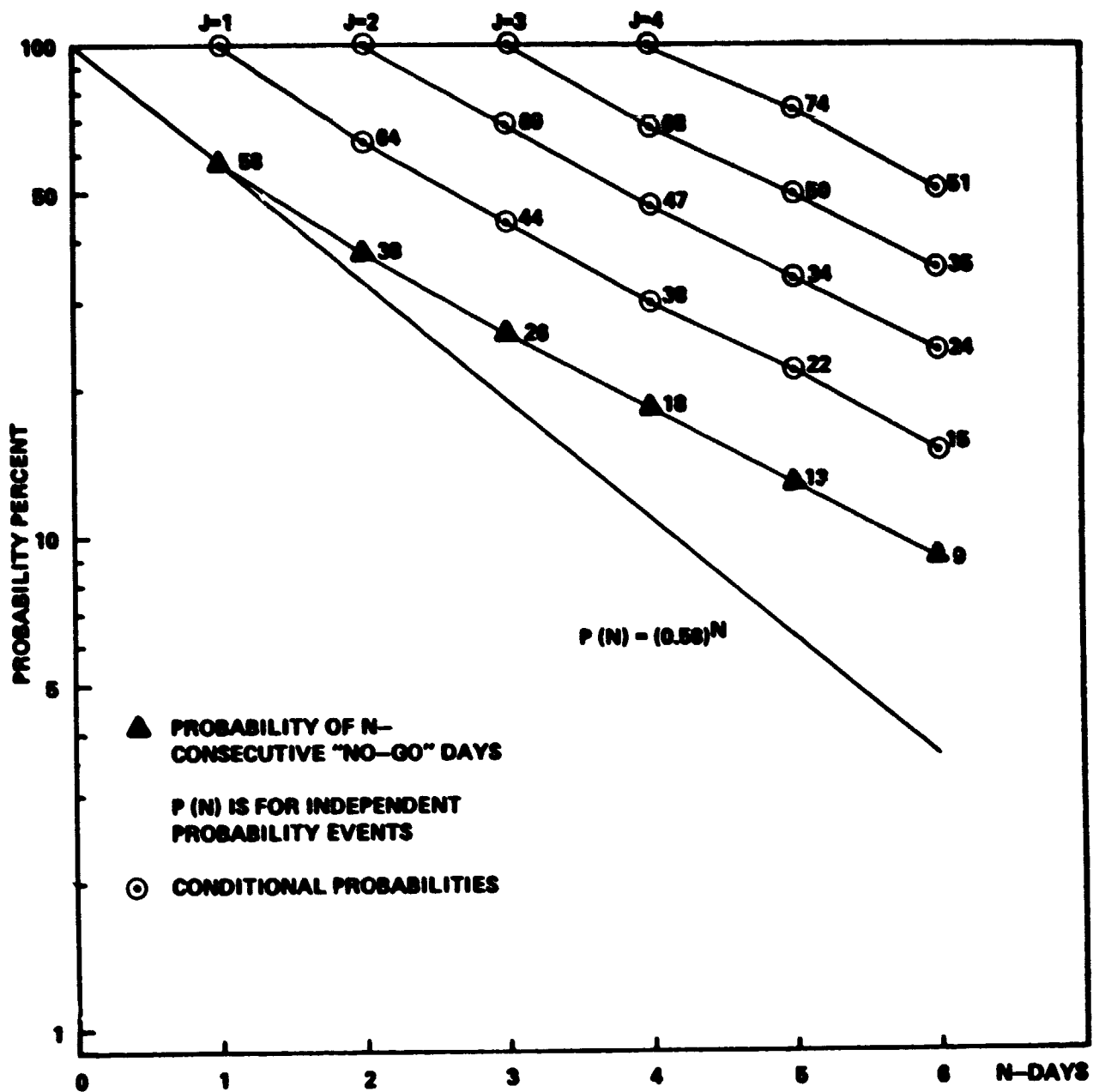


Figure 1. Conditional No-Go probabilities for Case I atmospheric constraints for EOM at 0900 LST, landing at KSC, Florida, January.

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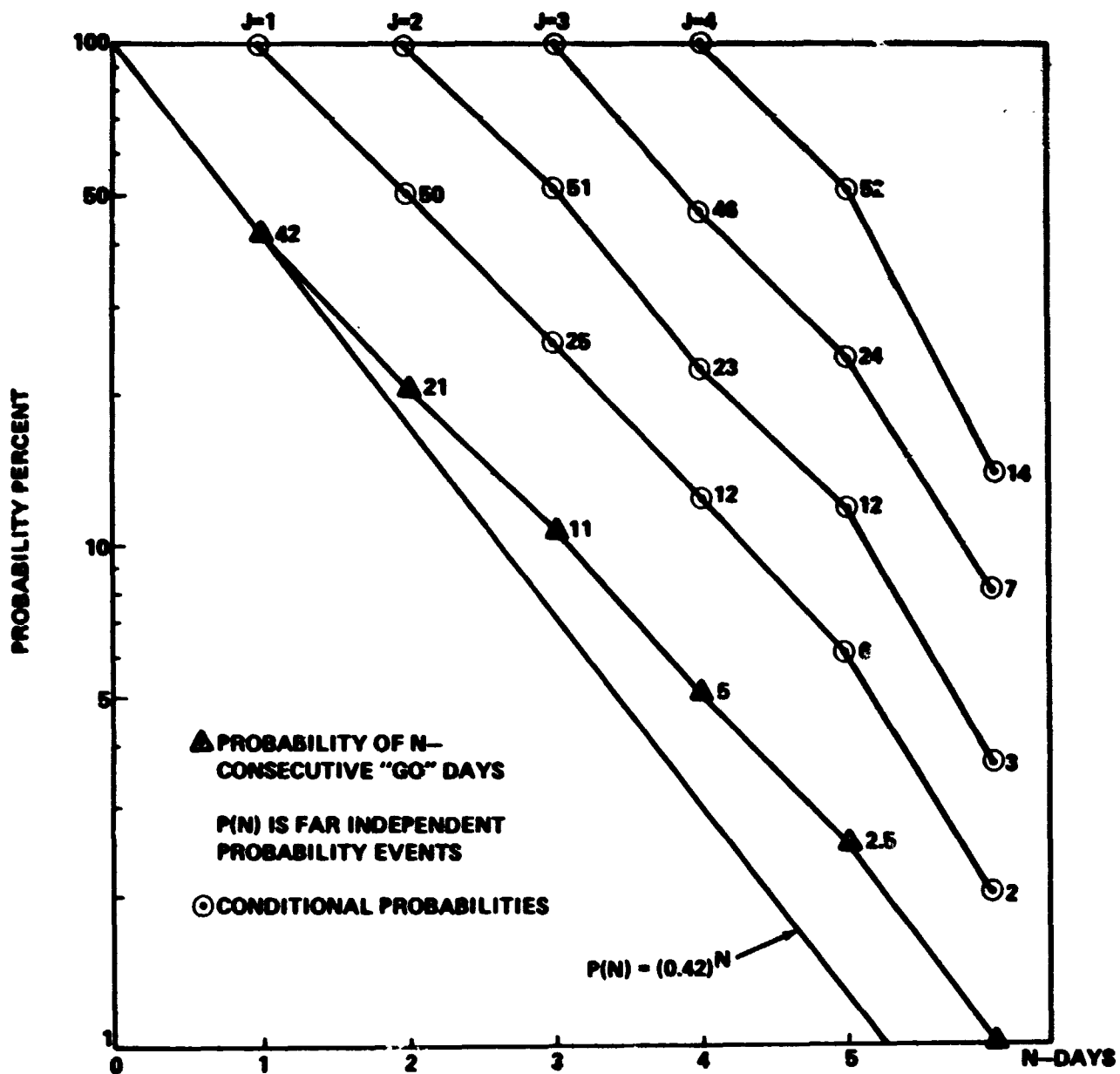


Figure 2. Conditional Go probabilities for Case I atmospheric constraints for EOM at 0900 LST, landing at KSC, Florida, January.

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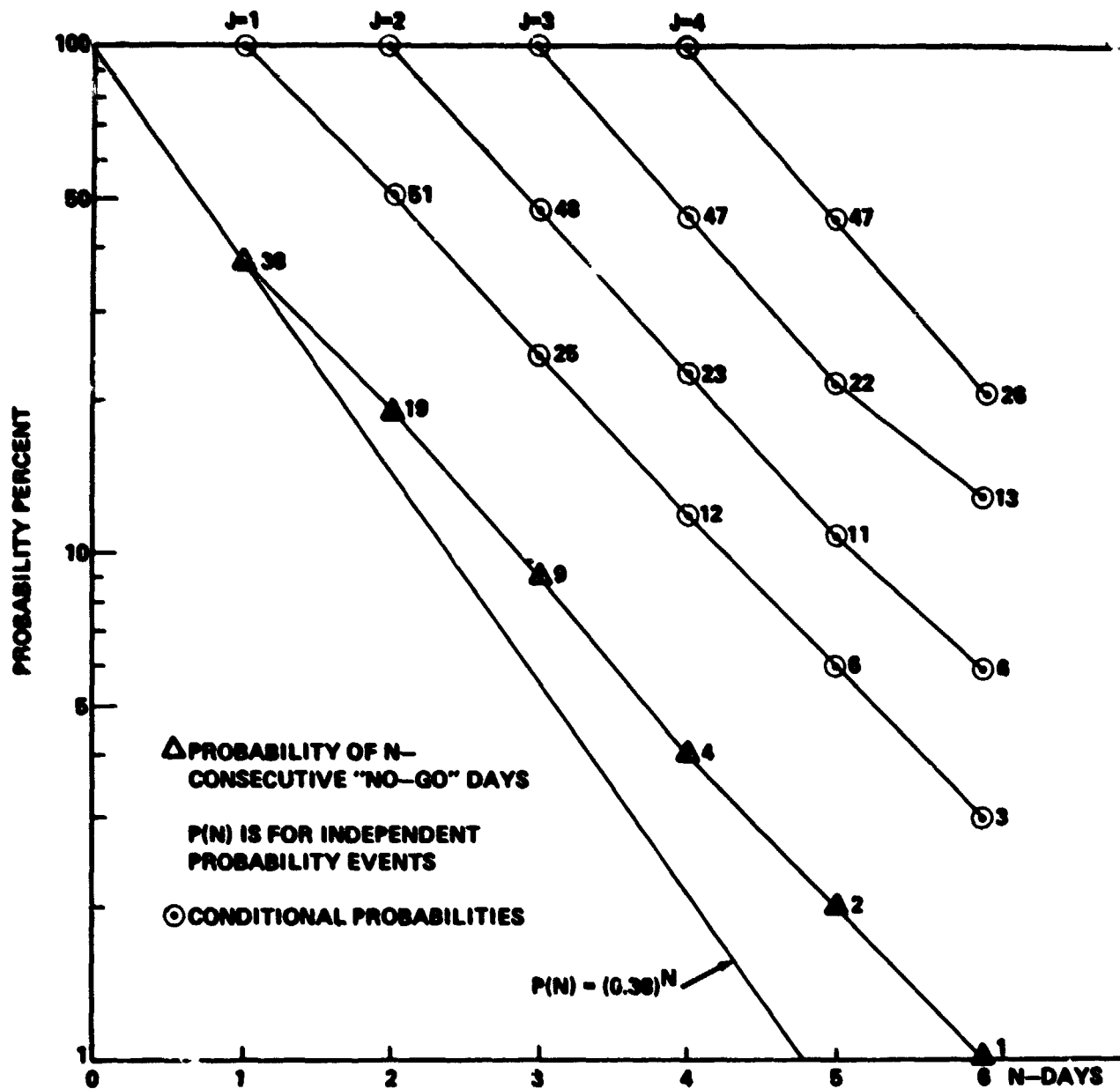


Figure 3. Conditional No-Go probabilities for Case I atmospheric constraints for EOM at 0900 L ST, landing at KSC, Florida, July.

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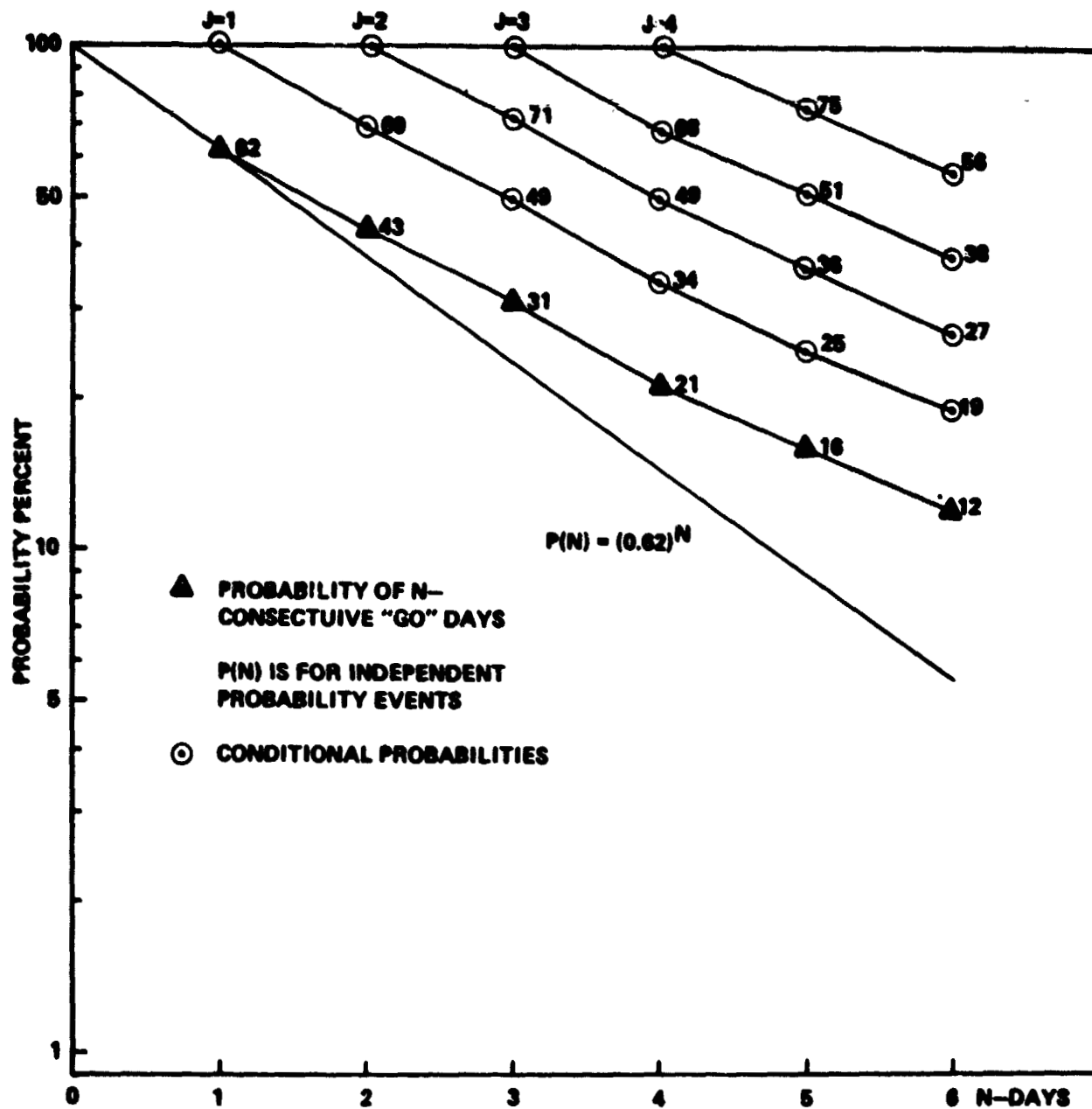


Figure 4. Conditional Go probabilities for Case I atmospheric constraints for EOM at 0900 LST, landing at KSC, Florida, July.

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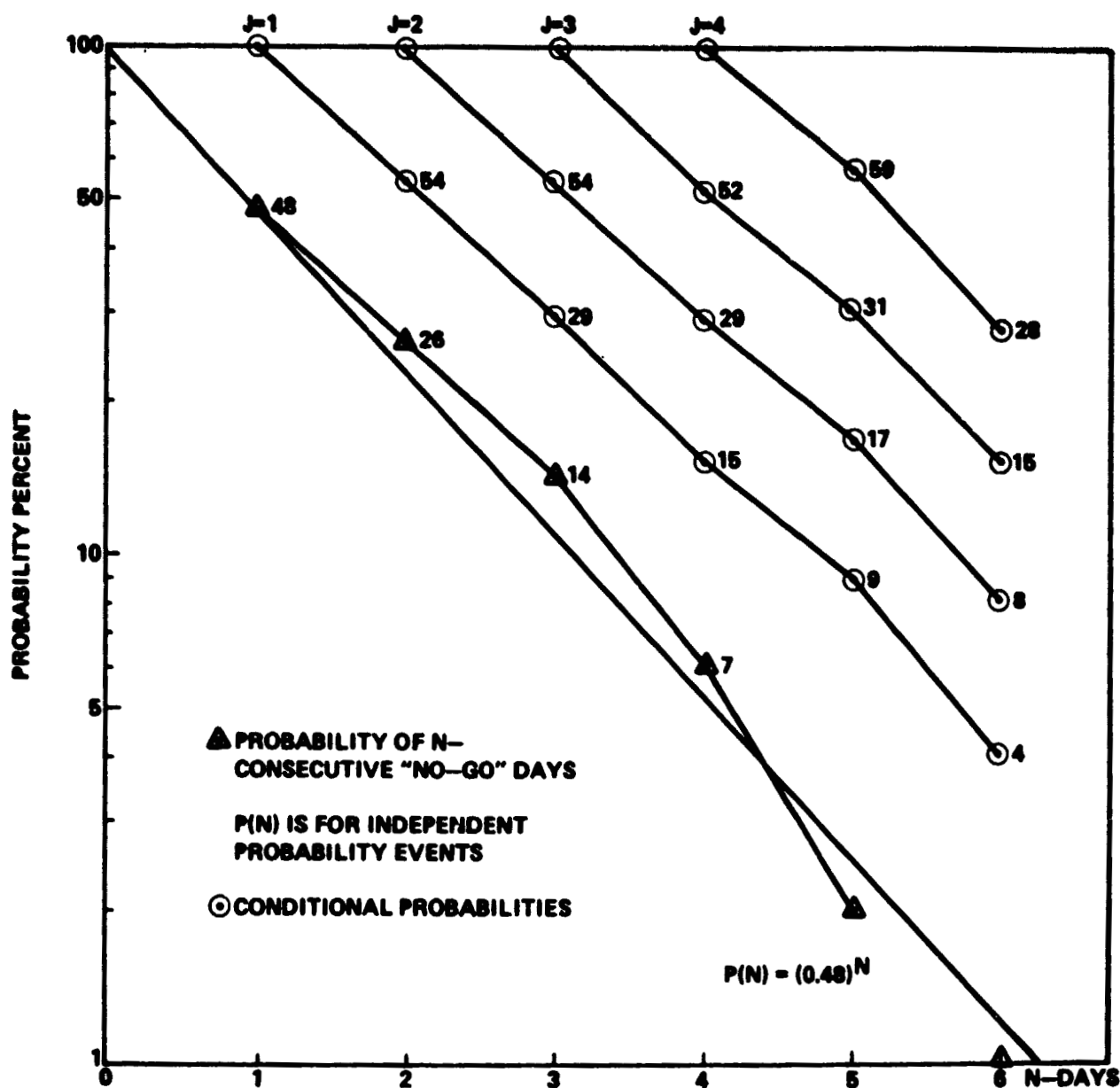


Figure 5. Conditional No-Go probabilities for Case II atmospheric constraints for EOM at 0900 LST, landing at KSC, Florida, January.

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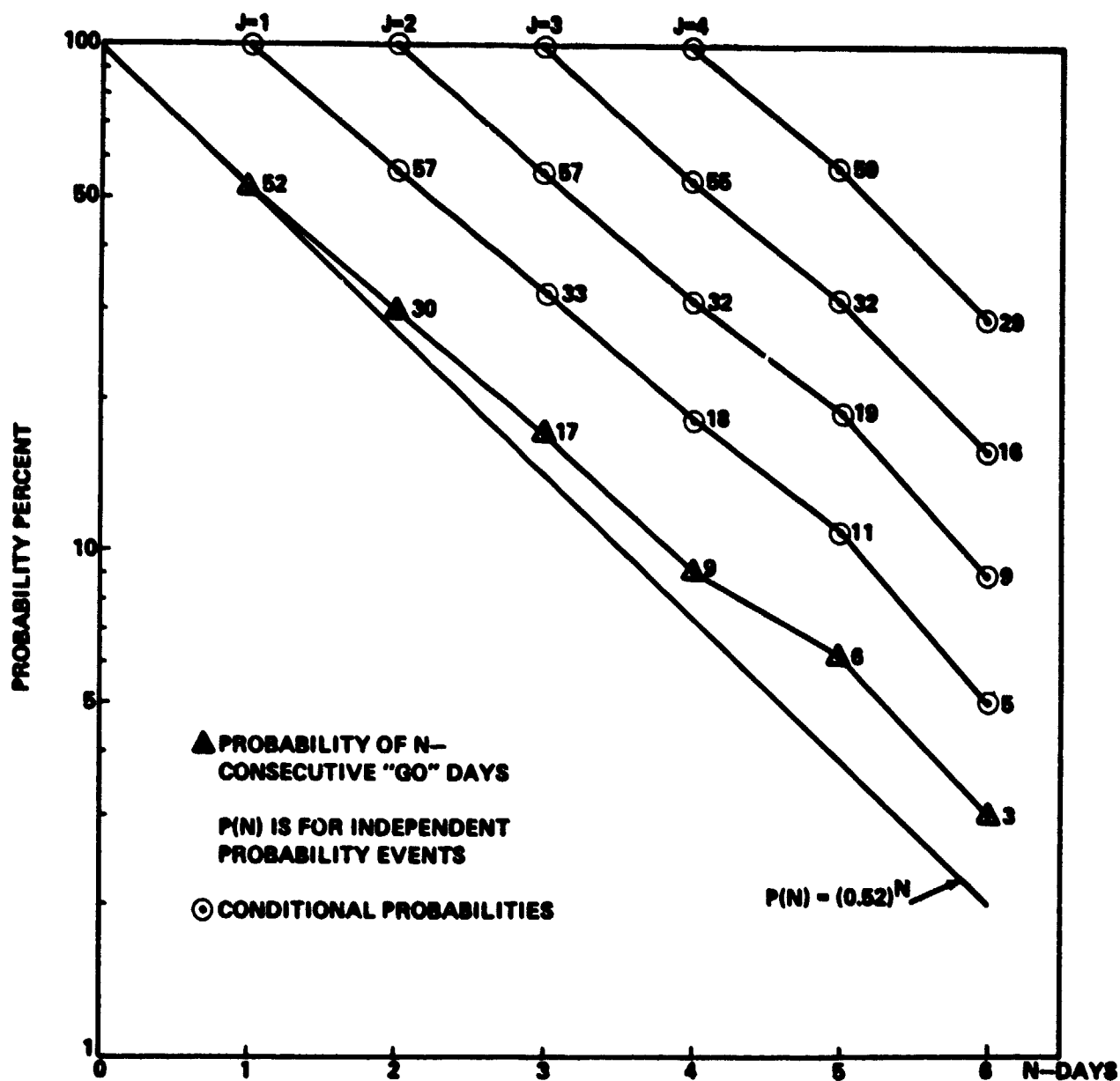


Figure 6. Conditional Go probabilities for Case II atmospheric constraints for EOM at 0900 LST, landing at KSC, Florida, January.

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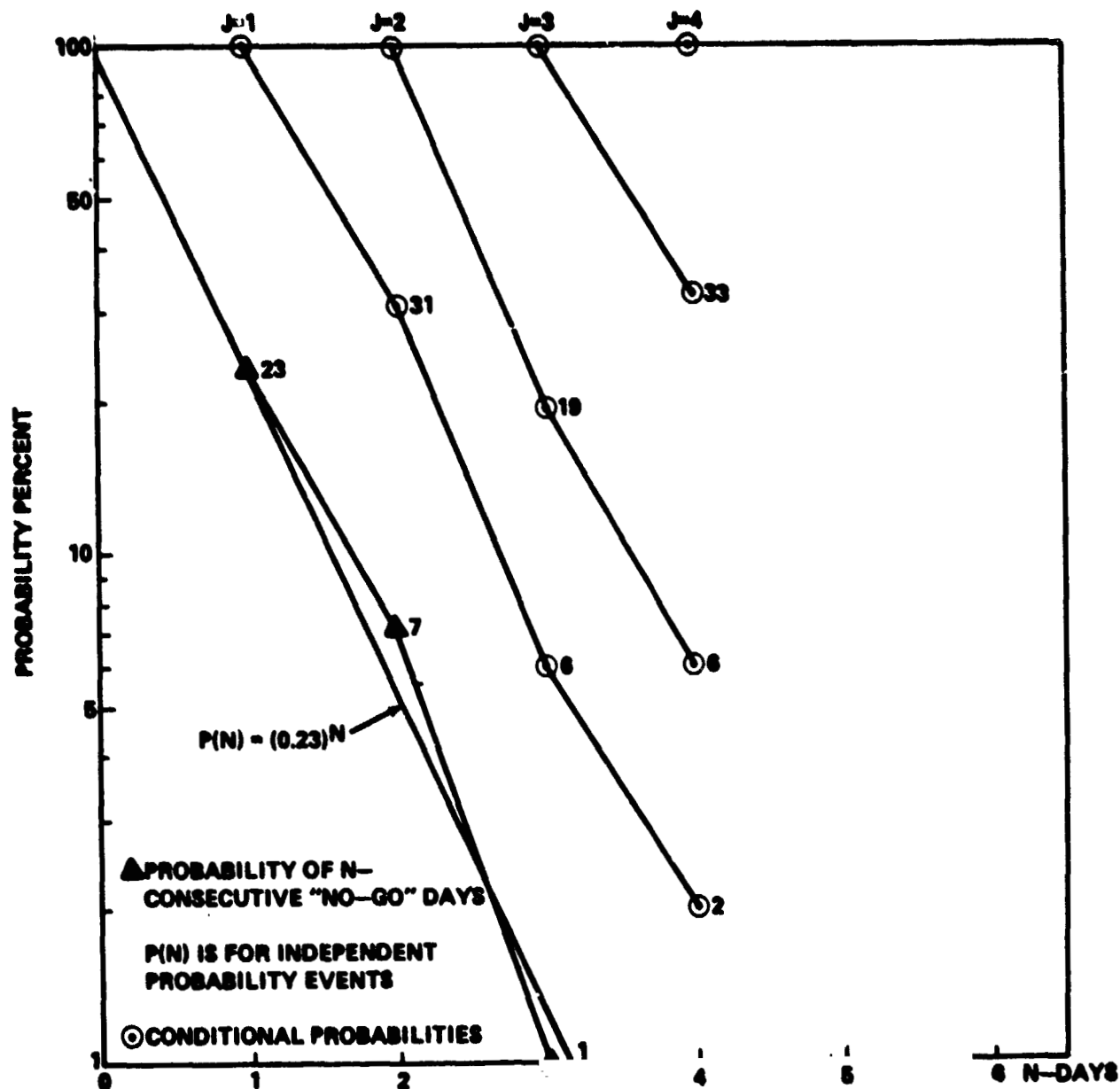


Figure 7. Conditional No-Go probabilities for Case II atmospheric constraints for EOM at 0900 LST, landing at KSC, Florida, July.

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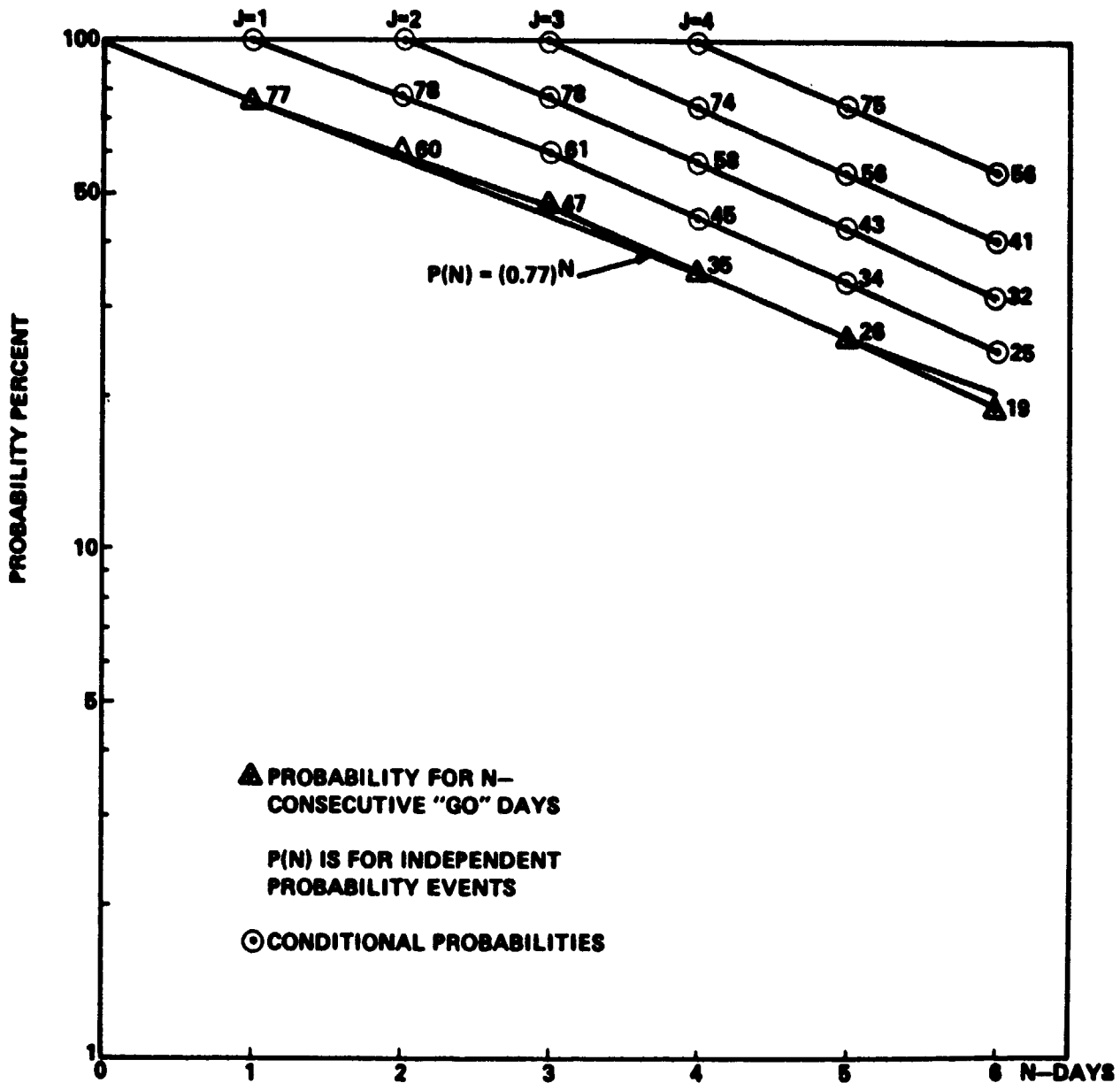


Figure 8. Conditional Go probabilities for Case II atmospheric constraints for EOM at 0900 LST, landing at KSC, Florida, July.

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